

DESCRIPTION

ULTRAVIOLET AND INFRARED ABSORPTIVE GREENISH GLASS

5 TECHNICAL FIELD

[0001] The present invention relates to an ultraviolet and infrared absorptive greenish glass that makes high inhabitability possible by having a relatively high transparency and infrared and ultraviolet shielding.

BACKGROUND OF THE INVENTION

10 [0002] Hitherto, from the viewpoint of energy conservation represented by the reduction of cooling load, there has been a social stream toward reducing the effect of infrared rays as much as possible. Such stream tends to be increased more and more due to the increase of interest about global warming

phenomena and environmental problems and the like. This stream brings
15 about various changes to glass industry. By providing glass itself or the glass surface with the absorption function and the reflection function, glasses that reduce the effect of infrared rays have been developed, and they have been commercialized as infrared absorptive glasses or infrared reflective glasses.

[0003] There is known a soda-lime-silica glass (see Patent Publication 1) that
20 has a composition comprising by weight % 66-75% SiO₂, 12-20% Na₂O, 7-12% CaO, 0-5% MgO, 0-4% Al₂O₃, 0-3% K₂O, 0-1% Fe₂O₃, and 0-1.5% of the total of CeO₂, TiO₂, V₂O₅ or MoO₃, that is a glass article in which the total iron is in at least 0.45 weight %, and its 35% or greater is of an iron that is in the ferrous iron condition represented by FeO, and less than 0.02 weight % of sulfur
25 expressed as SO₃ is contained, and that is of an infrared absorptive type showing a visible light transmittance (400-770nm) of at least 65% and an infrared transmittance (800-2100nm) of not greater than 15%.

[0004] There is a social movement towards reducing the effect of ultraviolet rays as much as possible, such as ultraviolet deterioration of organic materials
30 represented by fading phenomena and the occurrence of skin cancer by ultraviolet irradiation. In view of such movement, there is a study of a

commercial product that reduces the effect of ultraviolet rays by providing the glass itself or the glass surface with the ultraviolet absorptive function and reflective function. Its representative example is ultraviolet absorptive glass.

[0005] There is known an ultraviolet absorptive colored glass (see Patent Publication 2) which has a composition substantially comprising by weight % 65-75% SiO₂, 0.1-5 Al₂O₃, 10-18% Na₂O, 0-5% K₂O, 5-15% CaO, 1-6% MgO, 0.05-1.0% SO₃, 0.2-1.5% Ce moiety in terms of CeO₂, 0-1.0% Ti moiety in terms of TiO₂, 0.001-0.006% CoO, 0.3-1.6% Fe moiety in terms of Fe₂O₃, and in which 5-18 wt% of the Fe moiety in terms of Fe₂O₃ is of Fe²⁺.

[0006] There are described in this patent publication that the dominant wavelength measured with C light source is 488-492nm and the color purity is 3-4%, that the visible light transmittance measured at a thickness of 3-5 mm with A light source is 70% or greater, that the ultraviolet transmittance defined in ISO is 15% or less, that, if the content of CoO is less than 0.001%, the dominant wavelength becomes too long, thereby having a yellow color tone, and that, if it is greater than 0.006%, the dominant wavelength becomes too short, thereby not obtaining a bluish glass.

[0007] Furthermore, it has changed to a stream to simultaneously reduce the effect by ultraviolet rays and the effect by infrared rays. This stream is in a direction to increase more and more due to the increased interest in global warming phenomena and environmental problems and the like. In this stream, a so-called ultraviolet and infrared absorptive glass that absorbs both of ultraviolet rays and infrared rays attracts attention, in addition to conventional infrared absorptive glass and ultraviolet absorptive glass.

[0008] There is disclosed an infrared and ultraviolet absorptive, soda-lime-silica, greenish glass (see Patent Publication 3), which contains as major components 0.65-1.25 wt% Fe in terms of Fe₂O₃, 0.2-1.4 wt% CeO₂ or 0.1-1.36 wt% CeO₂ and 0.02-0.85 wt% TiO₂, and in which the weight ratio of FeO to Fe₂O₃ is fixed to have at a thickness of 3-5mm an Illuminant A visible light (wavelength 400-770nm) of 70% or greater, a total solar energy (wavelength:

300-2130nm) transmittance of 46% or less and an ultraviolet (wavelength 300-400nm) transmittance of 38% or less.

5 [0009] There are described in this patent publication that the above Fe is 0.48-0.92 wt% Fe_2O_3 and 0.15-0.33 wt% FeO, that the weight % of FeO constitutes a reduction percent of 23-29% of the total iron content expressed as Fe_2O_3 , that Illuminant C dominant wavelength is 498-525nm, that the color purity is 2-4%, and that 65-75wt% SiO_2 , 10-15wt% Na_2O , 0-4wt% K_2O , 1-5wt% MgO, 5-15wt% CaO and 0-3wt% Al_2O_3 are contained.

10 [0010] There is disclosed an infrared and ultraviolet absorptive glass (see Patent Publication 4), which substantially comprises in terms of oxide 65-75wt% SiO_2 , 0.1-5wt% Al_2O_3 , 10-18wt% Na_2O , 0-5wt% K_2O , 5-15wt% CaO, 1-6wt% MgO, 0.1-3wt% CeO_2 , 0.5-1.2wt% Fe_2O_3 , 0.05-1.0wt% SO_3 , and 0-1.0wt% TiO_2 , and in which 20-40% by weight of the total iron content expressed as Fe_2O_3 are in ferrous iron (FeO).

15 [0011] There are described in this patent publication that a coloring agent may be added to the glass of the above-mentioned compositional range to the extent that the total amount of one kind or two kinds or more of NiO, CoO, MnO, V_2O_5 , MoO_3 and the like is in 0-1.5wt%, that according to need 0-3wt% of ZnO may be added in order to prevent deterioration of color tone by ultraviolet
20 rays and coloring of amber, and that the visible transmittance (380-780nm) is 66.1-66.8%, the solar heat transmittance (340-1800nm) is 37.7-38.4%, and the dominant wavelength is 501-503nm (green color) at 5mm in thickness in examples.

25 [0012] There is disclosed an ultraviolet and infrared absorptive glass (see Patent Publication 5) which has a composition of 65-75% SiO_2 , 0-5% Al_2O_3 , 10-18% Na_2O , 0-5% K_2O , 5-15% CaO, 0-5% MgO, 0.1-3% CeO_2 , 0.2-1% FeO, and 0.1-3% SnO_2 in weight %, which contains 0-1.5% of a coloring agent such as NiO, CoO, MnO, V_2O_5 , MoO_3 and the like, 0-3% ZnO, and 0.1-3% SnO_2 , and in which the dominant wavelength is 488-497nm.

30 [0013] The present applicant also discloses an ultraviolet and infrared absorptive greenish glass (see Patent Publication 6) which contains by

weight % 67-75% SiO₂, 0.05-5% Al₂O₃, 12-16% Na₂O, 0.5-3% K₂O, 7-11% CaO, 2-4.2% MgO, 0.05-0.3% SO₃, 1.0-2.5% CeO₂, 0.1-1.0% TiO₂, 0.0010-0.0400% MnO, 0.0001-0.0009% CoO, and 0-1% SnO₂, and which has a composition of 70-76% of SiO₂+Al₂O₃+TiO₂, 10-15% of CaO+MgO, and 13-17% of Na₂O+K₂O.

5 [0014] Furthermore, even in the same ultraviolet and infrared absorptive glasses, their color tones are important. For example, green glass and blue glass are considered to be completely different commercial products. For example, it is actual that buildings that have been built are formed of similar color tones and that the color tones are also strictly managed, except an
10 extremely special example in which a pattern is formed of color difference. There has also been a case in which raw materials that have not been problematic so far are also limited due to the increased interest to the global environmental problems as compared with the past. Furthermore, the property requirement for various materials has become strict. Thus, there has
15 been a case of an extremely complicated condition in which raw materials and properties, which are usable for certain commercial products, cannot be used for other commercial products.

[0015] As mentioned above, the environment surrounding glass has greatly changed, and it is in a condition in which glasses satisfying the complicated
20 requirement specifications have not been developed sufficiently. In particular, it is a social demand for the development of an ultraviolet and infrared absorptive greenish glass of a predetermined green color tone and of not using selenium as a raw material.

Patent Publication 1: Japanese Patent Examined Publication 5-27578

25 Patent Publication 2: Japanese Patent Unexamined Publication 6-321677

Patent Publication 3: Japanese Patent Examined Publication 6-88812

Patent Publication 4: Japanese Patent Unexamined Publication 4-310539

Patent Publication 2: Japanese Patent Unexamined Publication 4-46031

Patent Publication 2: Japanese Patent Unexamined Publication 9-208254

30 SUMMARY OF THE INVENTION

[0016] It is an object of the present invention to provide a glass that achieves high performance infrared absorption and ultraviolet absorption together with a greenish color tone with a good balance, that has a sufficient transparency, and that has a predetermined greenish color tone.

5 According to the present invention, there is provided, in a soda-lime-silica series glass, an ultraviolet and infrared absorptive greenish glass, which is characterized in that, in an expression of weight %, it comprises at least coloring components of 0.3-0.5% of total Fe_2O_3 , 0.8-2.0% CeO_2 , 0.8-2.0% TiO_2 , and 0.10-0.25% FeO , and that the glass at 5mm thickness is 9% or less in
10 ultraviolet transmittance (T_{uv}) according to ISO/DIS9050, 1% or less in 350nm wavelength transmittance (T_{350}), 70% or greater in 550nm wavelength transmittance (T_{550}), and 25% or less in 1100nm wavelength transmittance (T_{1100}).

BRIEF DESCRIPTION OF THE DRAWINGS

15 [0017] Fig. 1 shows transmittance curves of Example 1-1 and Comparative Example 1-1.

Fig. 2 shows transmittance curves of Example 2-1 and Comparative Example 2-1.

DETAILED DESCRIPTION

20 [0018] According to the present invention, it is possible to obtain a glass that achieves high performance infrared absorption and ultraviolet absorption together with a greenish color tone with a good balance, that has a sufficient transparency, and that has a predetermined greenish color tone. It is possible to improve productivity with increased quality and yield and to produce with
25 stable operation without greatly changing the operation conditions and the plate forming conditions of the actual furnace in float process.

[0019] The present invention can be used for an electronic material field that requires ultraviolet and infrared absorptive properties, as well as conventional plate glass field such as architectural window glass and automotive window
30 glass.

[0020] The above-mentioned first glass may be an ultraviolet and infrared absorptive greenish glass (the second glass), in which CeO_2 is in an amount of 0.8-1.5% and TiO_2 is in an amount of 0.8-1.5%, and which further contains at least SnO of 0.1-0.7% as a coloring component. This second glass is also
5 characterized in that the second glass at 5mm thickness is 9% or less in ultraviolet transmittance (T_{uv}) according to ISO/DIS9050, 1% or less in 350nm wavelength transmittance (T_{350}), 70% or greater in 550nm wavelength transmittance (T_{550}), and 25% or less in 1100nm wavelength transmittance (T_{1100}). In other words, the second glass is one example of the first glass.

10 [0021] In the following, the ultraviolet and infrared absorptive, greenish, first and second glasses of the present invention are described in detail. In case that a description of each paragraph is not limited to either the first glass or the second glass of the present invention, the description is a description common to the first and second glasses.

15 [0022] Fe_2O_3 functions as a component that absorbs ultraviolet rays and secures a predetermined color tone, and is necessary for stably obtaining various optical properties. In relation to analysis, the sum of iron is expressed as Fe_2O_3 . It is, however, total Fe_2O_3 , since the form of FeO is included in this. In general, FeO absorbs infrared rays and is necessary, together with Fe_2O_3
20 that absorbs ultraviolet rays and secures a predetermined color tone, and together with each coloring factor such as CeO_2 and TiO_2 . That is, if total Fe_2O_3 is less than 0.3%, the function to the above becomes inferior. If it exceeds 0.5%, there occurs particularly a problem of lowering of the visible light transmittance. Total Fe_2O_3 component is more preferably in 0.35-0.45%
25 by weight %.

[0023] In the first glass, CeO_2 has mainly an ultraviolet absorptive function/effect. Its amount has been set to 0.8-2.0% by weight %, because there is a problem of an insufficient ultraviolet absorptive function in the case of less than 0.8%. On the other hand, if it exceeds 2%, the oxidation function
30 by CeO_2 becomes too strong, and the color tone of glass tends to have a yellowish color. Furthermore, there occurs a problem of the increase of the

raw material cost. More preferably, it is 0.9-1.9%. Further preferably, it is 1.0-1.8%.

[0024] Also in the second glass, CeO_2 has mainly an ultraviolet absorptive function/effect. Its amount has been set to 0.8-1.5% by weight %, because
5 there is a problem of an insufficient ultraviolet absorptive function in the case of less than 0.8%. On the other hand, if it exceeds 1.5%, the oxidation function by CeO_2 becomes too strong, and the color tone of glass tends to have a yellowish color. Furthermore, there occurs a problem of the increase of the raw material cost. More preferably, it is 0.9-1.4%. Further preferably, it is
10 1.0-1.3%.

[0025] In the first glass, similar to CeO_2 , TiO_2 also has mainly an ultraviolet absorptive function/effect. Its amount has been set to 0.8-2% by weight %, because there are in the case of less than 0.8% a problem of an insufficient ultraviolet absorptive function and a problem of the color tone of glass becomes
15 too blue in relation with other coloring components. On the other hand, if it exceeds 2%, there occur a problem in which the color tone of glass tends to have a yellowish color and a problem in which the visible light transmittance becomes too low. More preferably, it is 0.9-1.9%. Further preferably, it is 1.0-1.8%.

[0026] In the second glass, similar to CeO_2 , TiO_2 also has mainly an ultraviolet absorptive function/effect. Its amount has been set to 0.8-1.5% by weight %, because there are in the case of less than 0.8% a problem of an insufficient ultraviolet absorptive function and a problem of the color tone of glass becomes too blue in relation with other coloring components. On the
25 other hand, if it exceeds 1.5%, there occur a problem in which the color tone of glass tends to have a yellowish color and a problem in which the visible light transmittance becomes too low. More preferably, it is 0.9-1.4%. Further preferably, it is 1.0-1.3%.

[0027] In the second glass, it is preferable that SnO is added in a range of 0.1-0.7%. SnO has an effect of the reduction action and is effective for adjusting
30 the color tone. It is possible to reduce the contents of other coloring factors. It

is possible to increase the infrared absorptive capability and at the same time adjust the glass color tone. However, if SnO is less than 0.1%, the above-mentioned effect becomes small, and it becomes extremely difficult to obtain a color tone of green color. On the other hand, if it exceeds 0.7%, the reduction action becomes too strong. Amber tends to appear, and the color tone of glass has a strong bluish color tone. Therefore, the present color tone is not preferable. More preferably, it is 0.2-0.5%.

[0028] The reason why they have been set to the above-mentioned ranges is that each component is necessary for obtaining absorption of ultraviolet rays and infrared rays and a color tone of green color. Their balances are extremely important, and it is possible to obtain a desired greenish ultraviolet and infrared absorptive glass.

[0029] The reason why an ultraviolet and infrared absorptive greenish glass having an ultraviolet transmittance (T_{uv}) of not greater than 9% according to ISO/DIS9050 at 5mm thickness is preferable is that various deterioration problems occur by ultraviolet rays if it exceeds 9%. Herein, the ultraviolet transmittance (T_{uv}) according to ISO/DIS9050 represents a transmittance in a wavelength region of 297.5-377.5nm. Herein, the reason why it has been set to a wavelength region of 297.5-377.5nm is that both of a medium wavelength ultraviolet rays (UVB) of a wavelength of about 290-320 and a long wavelength ultraviolet rays (UVA) of about 320-400nm were taken into consideration.

[0030] The reason why an ultraviolet and infrared absorptive greenish glass having a 350nm wavelength transmittance (T_{350}) of not greater than 1% is preferable is that an effect referred to as a so-called ultraviolet deterioration is great and that problems occur if it exceeds 1%. Herein, the reason why it has been represented by a light of 350nm wavelength is that there has been taken into account a long wavelength ultraviolet rays (UVA) of a wavelength of about 320-400nm, that is, so-called A ultraviolet rays that, for example, are strong in penetration into human skin, that cause stain and sag by an action to fiber such as collagen fiber and elastic fiber in derma of skin, and that make stain and freckle inferior by an action to melanin present in skin.

[0031] The reason why an ultraviolet and infrared absorptive greenish glass having a 550nm wavelength transmittance (T_{550}) of not less than 70% at 5mm thickness is preferable is that there may occur a problem in transparency that is one great characteristic of glass if it is less than 70%. Herein, the reason why it has been represented by a 550nm wavelength light is that transmittance with green color is mainly considered.

[0032] The reason why an ultraviolet and infrared absorptive greenish glass having a 1100nm wavelength transmittance (T_{1100}) of not greater than 25% at 5mm thickness is preferable is that, for example, the cooling load increases and thereby it contradicts with global warming phenomena and environmental problems. Therefore, an ultraviolet and infrared absorptive greenish glass having a 1100nm wavelength transmittance (T_{1100}) of not greater than 15% at 5mm thickness may become preferable.

[0033] There is preferable the above ultraviolet and infrared absorptive greenish glass which comprises in weight % expression 67-75% SiO_2 , 0.5-3.0% Al_2O_3 , 7.0-11.0% CaO , 2.0-4.2% MgO , 12-16% Na_2O , 0.5-3.0% K_2O , and 0.05-0.3% SO_3 in addition to the above coloring components of glass, in which the sum of these components and the coloring components is 98% or greater, and in which $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{TiO}_2$ is 70-76%, $\text{CaO} + \text{MgO}$ is 10-15%, and $\text{Na}_2\text{O} + \text{K}_2\text{O}$ is 13-17%.

[0034] The reason why SiO_2 component has been set to 67-75% by weight % is that the surface tends to have stain or the like, weather resistance lowers, and a practical problem occurs if it is less than 67%. If it exceeds 75%, melting also becomes difficult.

[0035] The reason why Al_2O_3 component has been set to 0.5-3.0% by weight % is that weather resistance lowers, the surface tends to have stain or the like, and a practical problem occurs if it is less than 0.5%. On the other hand, if it exceeds 3%, devitrification tends to occur. Therefore, the forming temperature range becomes narrow, resulting in difficulty in production.

[0036] The reason why CaO component has been set to 7.0-11.0% by weight % is that the melting temperature becomes high since flux tends to be

insufficient, and the production becomes difficult since the flow temperature does not become low, if it is less than 7.0%. On the other hand, if it exceeds 11%, devitrification tends to occur, and the production becomes difficult since the forming operation range becomes narrow.

5 [0037] The reason why MgO component has been set to 2.0-4.2% by weight % is that the melting temperature increases to narrow the operation range, thereby making the production difficult, if it is less than 2.0%, and that meltability becomes inferior if it exceeds 4.2%.

10 [0038] The reason why Na₂O component has been set to 12.0-16.0% by weight% is that meltability becomes inferior and tempering easiness lowers, forming becomes difficult, and the production becomes difficult since devitrification tends to occur and the operation range narrows, if it is less than 12.0. On the other hand, if it exceeds 16%, weather resistance lowers, and the surface tends to have stain or the like, resulting in the occurrence of a
15 practical problem.

[0039] The reason why K₂O component has been set to 0.5-3.0% is that tempering easiness lowers if it is less than 0.5%, and weather resistance lowers and the cost increases if it is greater than 3.0%.

20 [0040] The reason why SO₃ component has been set to 0.05-0.3% is that, for example, deforming or homogeneity tends to become insufficient in normal melting if it is less than 0.05%. If it exceeds 0.3%, the coloring condition of glass is particularly affected. For example, it tends to have a color tone of yellow or amber-like color, and it becomes impossible to obtain a desired greenish color tone. It is preferably 0.1-0.2%.

25 [0041] The reason why the total of the components of SiO₂, Al₂O₃, CaO, MgO, Na₂O, K₂O, SO₃, Fe₂O₃, CeO₂ and TiO₂ has been set to 98% or greater by weight percent in the first glass is that the total of minor components, such as CoO, Cr₂O₃ and SnO, which may be added in some cases, is made not to exceed 2%.

30 [0042] The reason why the total of the components of SiO₂, Al₂O₃, CaO, MgO, Na₂O, K₂O, SO₃, Fe₂O₃, CeO₂ and TiO₂ has been set to 98% or greater by

weight percent in the second glass is that the total of minor components, such as CoO , Cr_2O_3 , V_2O_5 and MoO , which may be added in some cases, is made not to exceed 2%.

[0043] Furthermore, the reason why $\text{SiO}_2+\text{Al}_2\text{O}_3+\text{TiO}_2$ has been set to 70-76%
5 by weight percent is that weather resistance lowers if it is less than 70% and that a problem of the decrease of tempering easiness occurs if it is greater than 76%. It is preferably about 70-74%.

[0044] The reason why $\text{CaO}+\text{MgO}$ has been set to 10-15% by weight percent to use CaO and MgO components for lowering the melting temperature.

10 Furthermore, tempering easiness lowers if it is less than 10%. If it exceeds 15%, devitrification tends to occur, thereby making the production difficult. It is preferably about 11.5-15%.

[0045] The reason why $\text{Na}_2\text{O}+\text{K}_2\text{O}$ has been set to 13-17% by percent is that tempering easiness lowers, devitrification also tends to occur, and the
15 operation temperature range upon forming narrows, thereby making the production difficult, if it is less than 13%. On the other hand, if it exceeds 17%, weather resistance lowers, a practical problem occurs, and the cost increases.

[0046] Furthermore, there is preferable an ultraviolet and infrared absorptive greenish glass in which $\text{FeO}/\text{Fe}_2\text{O}_3$ is 0.3-0.6 in weight ratio expression and
20 $\text{CeO}_2/\text{TiO}_2$ is 0.7-1.3 in weight ratio expression. FeO and Fe_2O_3 are generally different in their functions. Mainly, Fe_2O_3 has a considerable influence on the ultraviolet region, and FeO has a considerable influence on the infrared region. Therefore, although they are the same iron components, it is preferable to control their proportions. If $\text{FeO}/\text{Fe}_2\text{O}_3$ in weight ratio expression is less than
25 30%, there occurs a problem in which infrared absorption is low, resulting in too high solar radiation transmittance. On the other hand, $\text{FeO}/\text{Fe}_2\text{O}_3$ in weight ratio expression exceeds 0.6, the solar radiation transmittance becomes low; however, there occurs a problem in which the color tone of glass becomes too blue. More preferably, it is in a range of 0.4-0.6.

30 [0047] CeO_2 and TiO_2 have an absorptive function/effect of mainly ultraviolet rays. However, they are different from each other in terms of influence on the

absorptive function of ultraviolet rays and make a difference in color tone.

Therefore, it is preferable to set the range of $\text{CeO}_2/\text{TiO}_2$ in weight ratio

expression. If $\text{CeO}_2/\text{TiO}_2$ in weight ratio expression is less than 0.7, there

occurs a problem of insufficient ultraviolet absorptive action. On the other

5 hand, if $\text{CeO}_2/\text{TiO}_2$ in weight ratio expression exceeds 1.3, there occurs a

problem in which the color tone of glass tends to become yellowish in relation

with other coloring raw materials. More preferably, it is in a range of 0.8-1.2.

Further preferably, it is in a range of 0.85-1.15.

[0048] Furthermore, it is preferable that the visible light transmittance (T_v)

10 by A light source at 5mm thickness is 67% or greater. This is because there

occurs a problem in transparency performance that is one of significant

characteristics of glass. More preferably, it is 70% or greater, since it is likely

to have lowering of transparency of glass particularly in an automotive front

window glass and lowering of object identification particularly upon sunset,

15 night or rain. Herein, the visible light region refers to a wavelength range of 380-780nm.

[0049] An ultraviolet and infrared absorptive greenish glass having a solar

radiation transmittance (T_s) of 48% or less is preferable. If it exceeds 48%, for

example, the cooling load increases, thereby contradicting with global warming

20 phenomena and environmental problems. That is, if it exceeds 48%, the

cooling load increases, or the actual feeling of the effect of improving

inhabitability of car or room interior diminishes. In particular, it becomes

difficult to eliminate uncomfortableness in midsummer or the like. Therefore,

it becomes impossible to sufficiently obtain the energy saving effect.

25 [0050] Furthermore, an ultraviolet and infrared absorptive greenish glass

having a dominant wavelength (D) by D_{65} light source of 510-560nm and an

excitation purity (P_e) of 10% or less is preferable. This dominant wavelength

(D) and the excitation purity (P_e) are useful for setting coloring of the

ultraviolet and infrared absorptive greenish glass. As the color tone, the

30 dominant wavelength (D) by D_{65} light source is preferably in 510-560nm. If

the dominant wavelength (D) by D_{65} light source is in a region shorter than

510nm, the color tone of green color becomes unsharp, and it becomes a so-called bluish color, resulting in no match with market needs preferring "deep green color". On the other hand, if the dominant wavelength (D) by D₆₅ light source exceeds 560nm, a yellow color or amber color increases. This also does not match with market needs preferring "deep green color". More preferably, it is a range of 520-540nm. On the other hand, if excitation purity (Pe) exceeds 10%, it becomes too strong; resulting in no match with recent market needs preferring an "elegant" coloring.

[0051] Furthermore, it is preferable that 5-50ppm of Cr₂O₃ is contained as a coloring component in weight % expression. If it is less than 5ppm, there occurs a problem in which the color tone of glass becomes a yellowish color tone. On the other hand, if it exceeds 30ppm, there occurs a problem in which the visible light transmittance become too low. More preferably, it is a range of 10-25ppm.

[0052] Although MnO is not essential, the addition of 200ppm or less is preferable. This is because MnO has an effect of reduction action. However, if it exceeds 200ppm, there occurs a problem in which the reduction action becomes too strong and amber tends to occur. Therefore, it is not preferable.

[0053] In the first glass, although SnO is not essential, it may be added in 1.0% or less. This is because SnO has an effect of reduction action. However, if it exceeds 1.0%, there occur problems in which the reduction action becomes too strong and amber tends to occur and in which the color tone of glass becomes a strongly bluish color tone. Therefore, it is not preferable.

[0054] To produce an ultraviolet and infrared absorptive greenish glass of the present invention, it is optional to use a frit glass, cullet or the like containing coloring components such as Fe₂O₃, CeO₂, TiO₂, FeO, Cr₂O₃, MnO, and SnO. The quantitative adjustment of these components tends to become stable.

Inclusion of FeO into glass becomes easy. The operation can be conducted in a manner to stabilize the oxidation-reduction condition of glass without greatly changing operation conditions and the like of the actual furnace. Upon adding the above-mentioned coloring components, it is possible to use carbon or a

metal powder or oxide or the like of Zn. It is effective for the case of securing color tone or the like, for example, while helping fining function/effect by mirabilite (Na_2SO_4) or the like. Furthermore, in some cases, in the atmosphere of the adjustment region of glass furnace, the stabilization may be achieved by introducing nitrogen gas or its mixed gas or combustion exhaust gas.

[0055] An ultraviolet and infrared absorptive greenish glass of the present invention contains an easy-tempering glass composition, too. It is effective particularly for thin plate glasses having a plate thickness of about 1.5-3.5mm, which are strength-increased products, semi-tempered products and tempered products as flat plates or curved plates. They can be used particularly as window glasses such as automobiles and train vehicles. It is possible to use them as architectural window members from thin plate glasses having a plate thickness of about 1mm to thick plate glasses having a plate thickness of about 25mm, as single plate glass, laminated glass, lamination glass or double glazing.

[0056] The following examples are illustrative of the present invention. In particular, the following Examples 1-1 to 1-5 correspond to the first glass of the present invention, and Examples 2-1 to 2-5 correspond to the second glass of the present invention. As stated above, however, the second glass is one example of the first glass. Therefore, it is needless to say that Examples 2-1 to 2-5 correspond to the first glass, too.

(EXAMPLE 1-1)

[0057] As glass raw materials, there were used silica sand, feldspar, soda ash, dolomite, limestone, mirabilite, rouge, titanium oxide, and cerium carbonate. Furthermore, there were also used chemical reagents of Al_2O_3 , Fe_2O_3 , CaCO_3 , MgCO_3 , Na_2CO_3 , K_2CO_3 , CeO_2 and TiO_2 , in addition to ilmenite, carbon and slug. Using these, a predetermined glass composition was previously set as a target composition, and they were weighed and mixed together. As a raw material batch, mirabilite/(silicon sand + feldspar) was adjusted to about 1%, and cullet was adjusted to about 50%.

[0058] The mixed raw material was put into a crucible. It was melted for about 3-4 hours for vitrification in an actual furnace (for example, a wall portion on a lateral side of an inlet, a side wall portion of a condition portion), which was maintained at about 1450°C, or in an electric furnace made to be similar to the actual furnace while using nitrogen gas or a mixed gas containing the gas or the like. Furthermore, it was maintained at 1420-1430 °C for about 2hr for homogenization and fining. Then, it was poured into mold. It was cut into a glass plate having a size of 100mm×100mm and a thickness of about 3.5mm as a glass block, or the glass was allowed to flow out to form a plate having a size of 100mm×100mm and a thickness of about 3.5mm. Then, it was ground and polished, thereby obtaining each sample.

[0059] The glass component composition (weight %) of this sample was measured by a wet analysis according to JIS R-3101 or the like, and its optical characteristics were measured by a 340-type automated spectrophotometer made by Hitachi Ltd. and JIS Z-8722, JIS R-3106 and ISO/DIS 9050.

[0060] The glass composition was in weight expression 70.1% SiO₂, 1.8% Al₂O₃, 8.2% CaO, 3.6% MgO, 12.6% Na₂O, 0.9% K₂O, 0.1% SO₃, 0.42% total Fe₂O₃, 1.1% CeO₂, 1.1% TiO₂, and 17ppm Cr₂O₃. FeO was in 0.21%. FeO/Fe₂O₃ was 0.5 in weight ratio expression. CeO₂/TiO₂ was 1.0 in weight ratio expression.

The total of SiO₂+Al₂O₃+Fe₂O₃+CaO+MgO+Na₂O+K₂O+SO₃+CeO₂+TiO₂+Cr₂O₃+MnO was in 99.9%. SiO₂+Al₂O₃+TiO₂ was in 72.8%. CaO+MgO was in 11.8%. Na₂O+K₂O was in 13.5%.

[0061] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 4.6%. 350nm wavelength transmittance (T₃₅₀) was in 0%. 550nm wavelength transmittance (T₅₅₀) was in 78%. 1100nm wavelength transmittance (T₁₁₀₀) was in 10%. The visible light transmittance (T_v) by A light source was in 68%. The solar radiation transmittance (T_s) was in 36%. The dominant wavelength (D) by D₆₅ light source was in 535nm. Excitation purity (Pe) was in 5%. The measurement results, converted to 5mm thickness, of transmittance relative to wavelength are shown in Fig. 1. It is understood

that transmittance of ultraviolet and infrared region is low and that it has a characteristic of ultraviolet absorption and infrared absorption.

(EXAMPLE 1-2)

[0062] Using glass raw materials almost similar to Example 1-1, an examination was continued by changing the glass composition. As a result, the glass composition was in weight expression 70.2% SiO₂, 1.8% Al₂O₃, 8.2% CaO, 3.6% MgO, 12.7% Na₂O, 0.9% K₂O, 0.1% SO₃, 0.32% total Fe₂O₃, 1.0% CeO₂, 1.0% TiO₂, and 13ppm Cr₂O₃. FeO was in 0.15%. FeO/Fe₂O₃ was 0.47 in weight ratio expression. CeO₂/TiO₂ was 1.0 in weight ratio expression. The total of SiO₂+Al₂O₃+Fe₂O₃+CaO+MgO+Na₂O+K₂O+SO₃+CeO₂+TiO₂+Cr₂O₃+MnO was in 99.8%. SiO₂+Al₂O₃+TiO₂ was in 73.0%. CaO+MgO was in 11.8%. Na₂O+K₂O was in 13.8%.

[0063] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 8.5%. 350nm wavelength transmittance (T₃₅₀) was in 1%. 550nm wavelength transmittance (T₅₅₀) was in 79%. 1100nm wavelength transmittance (T₁₁₀₀) was in 21%. The visible light transmittance (T_v) by A light source was in 75%. The solar radiation transmittance (T_s) was in 46%. The dominant wavelength (D) by D₆₅ light source was in 543nm. Excitation purity (Pe) was in 4%.

(EXAMPLE 1-3)

[0064] Using glass raw materials almost similar to Example 1-1, an examination was continued by changing the glass composition. As a result, the glass composition was in weight expression 69.5% SiO₂, 1.6% Al₂O₃, 8.0% CaO, 3.7% MgO, 12.4% Na₂O, 1.0% K₂O, 0.1% SO₃, 0.32% total Fe₂O₃, 1.4% CeO₂, 1.9% TiO₂, 7ppm Cr₂O₃, 180ppm MnO, and 0.2% SnO₂. FeO was in 0.135%. FeO/Fe₂O₃ was 0.42 in weight ratio expression. CeO₂/TiO₂ was 0.7 in weight ratio expression. The total of SiO₂+Al₂O₃+Fe₂O₃+CaO+MgO+Na₂O+K₂O+SO₃+CeO₂+TiO₂+Cr₂O₃+MnO was in 99.9%. SiO₂+Al₂O₃+TiO₂ was in 73.0%. CaO+MgO was in 11.7%. Na₂O+K₂O was in 13.4%.

[0065] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 4.4%. 350nm wavelength transmittance (T_{350}) was in 0%. 550nm wavelength transmittance (T_{550}) was in 76%. 1100nm wavelength transmittance (T_{1100}) was in 20%. The visible light transmittance (T_v) by A light source was in 73%. The solar radiation transmittance (T_s) was in 46%. The dominant wavelength (D) by D₆₅ light source was in 550nm. Excitation purity (Pe) was in 3%.

(EXAMPLE 1-4)

[0066] Using glass raw materials almost similar to Example 1-1, an examination was continued by changing the glass composition. As a result, the glass composition was in weight expression 70.3% SiO₂, 1.7% Al₂O₃, 8.2% CaO, 3.6% MgO, 12.6% Na₂O, 0.9% K₂O, 0.1% SO₃, 0.45% total Fe₂O₃, 1.0% CeO₂, 1.0% TiO₂, 20ppm Cr₂O₃, 80ppm MnO, and 0.2% SnO₂. FeO was in 0.158%. FeO/Fe₂O₃ was 0.30 in weight ratio expression. CeO₂/TiO₂ was 1.0 in weight ratio expression. The total of SiO₂+Al₂O₃+Fe₂O₃+CaO+MgO+Na₂O+K₂O+SO₃+CeO₂+TiO₂+Cr₂O₃+MnO was in 99.8%. SiO₂+Al₂O₃+TiO₂ was in 73.0%. CaO+MgO was in 11.8%. Na₂O+K₂O was in 13.5%.

[0067] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 4.0%. 350nm wavelength transmittance (T_{350}) was in 0%. 550nm wavelength transmittance (T_{550}) was in 72%. 1100nm wavelength transmittance (T_{1100}) was in 8%. The visible light transmittance (T_v) by A light source was in 67%. The solar radiation transmittance (T_s) was in 34%. The dominant wavelength (D) by D₆₅ light source was in 535nm. Excitation purity (Pe) was in 5%.

(EXAMPLE 1-5)

[0068] Using glass raw materials almost similar to Example 1-1, an examination was continued by changing the glass composition. As a result, the glass composition was in weight expression 69.3% SiO₂, 1.6% Al₂O₃, 8.2% CaO, 3.6% MgO, 12.6% Na₂O, 0.9% K₂O, 0.1% SO₃, 0.38% total Fe₂O₃, 1.8% CeO₂, 1.4% TiO₂, 25ppm Cr₂O₃, and 80ppm MnO. FeO was in 0.200%.

FeO/Fe₂O₃ was 0.53 in weight ratio expression. CeO₂/TiO₂ was 1.3 in weight ratio expression. The total of SiO₂+Al₂O₃+Fe₂O₃+CaO+MgO+Na₂O+K₂O+SO₃+CeO₂+TiO₂+Cr₂O₃+MnO was in 99.9%. SiO₂+Al₂O₃+TiO₂ was in 72.3%. CaO+MgO was in 11.8%.

5 Na₂O+K₂O was in 13.5%.

[0069] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 3.5%. 350nm wavelength transmittance (T₃₅₀) was in 0%. 550nm wavelength transmittance (T₅₅₀) was in 70%. 1100nm wavelength transmittance (T₁₁₀₀) was in 13%. The visible light transmittance (T_v) by A
10 light source was in 76%. The solar radiation transmittance (T_s) was in 45%. The dominant wavelength (D) by D₆₅ light source was in 550nm. Excitation purity (Pe) was in 5%.

(COMPARATIVE EXAMPLE 1-1)

[0070] Using glass raw materials almost similar to Example 1-1, the coloring
15 raw materials in the glass composition were changed. As a result, the glass composition was in weight expression 71.2% SiO₂, 1.9% Al₂O₃, 8.3% CaO, 3.7% MgO, 13.0% Na₂O, 0.9% K₂O, 0.2% SO₃, 0.62% total Fe₂O₃, 0.1% TiO₂, and 7ppm CoO. FeO was in 0.12%. FeO/Fe₂O₃ was 0.19 in weight ratio expression. CeO₂/TiO₂ was 0 in weight ratio expression. The total of
20 SiO₂+Al₂O₃+Fe₂O₃+CaO+MgO+Na₂O+K₂O+SO₃+CeO₂+TiO₂+Cr₂O₃+MnO was in 99.9%. SiO₂+Al₂O₃+TiO₂ was in 73.2%. CaO+MgO was in 12.0%. Na₂O+K₂O was in 13.9%.

[0071] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 25%. 350nm wavelength transmittance (T₃₅₀) was in 20%. 550nm
25 wavelength transmittance (T₅₅₀) was in 79%. 1100nm wavelength transmittance (T₁₁₀₀) was in 24%. The visible light transmittance (T_v) by A light source was in 76%. The solar radiation transmittance (T_s) was in 50%. The dominant wavelength (D) by D₆₅ light source was in 500nm. Excitation purity (Pe) was in 3%. The measurement results, converted to 5mm thickness,
30 of transmittance relative to wavelength, together with the results of Example 1, are shown in Fig. 1. Although it is a greenish glass, its transmittance of

ultraviolet rays and infrared rays is high, and its characteristics are different from those of the ultraviolet and infrared absorptive glass of Example 1-1.

(COMPARATIVE EXAMPLE 1-2)

[0072] Using glass raw materials almost similar to Example 1-1, the coloring raw materials in the glass composition were changed. As a result, the glass composition was in weight expression 70.1% SiO₂, 1.6% Al₂O₃, 8.2% CaO, 3.6% MgO, 12.6% Na₂O, 0.9% K₂O, 0.1% SO₃, 0.62% total Fe₂O₃, 0.7% CeO₂, 0.5% TiO₂, 55ppm Cr₂O₃, and 220ppm MnO. FeO was in 0.15%. FeO/Fe₂O₃ was 0.25 in weight ratio expression. CeO₂/TiO₂ was 1.4 in weight ratio expression.

The total of

SiO₂+Al₂O₃+Fe₂O₃+CaO+MgO+Na₂O+K₂O+SO₃+CeO₂+TiO₂+Cr₂O₃+MnO was in 98.9%. SiO₂+Al₂O₃+TiO₂ was in 72.2%. CaO+MgO was in 11.8%. Na₂O+K₂O was in 13.5%.

[0073] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 10%. 350nm wavelength transmittance (T₃₅₀) was in 2.2%. 550nm wavelength transmittance (T₅₅₀) was in 65%. 1100nm wavelength transmittance (T₁₁₀₀) was in 18%. The visible light transmittance (T_v) by A light source was in 73%. The solar radiation transmittance (T_s) was in 45%. The dominant wavelength (D) by D₆₅ light source was in 506nm. Excitation purity (Pe) was in 3%.

(COMPARATIVE EXAMPLE 1-3)

[0074] Using glass raw materials almost similar to Example 1-2, the coloring raw materials in the glass composition were changed. As a result, the glass composition was in weight expression 68.5% SiO₂, 1.8% Al₂O₃, 8.2% CaO, 3.6% MgO, 12.7% Na₂O, 0.9% K₂O, 0.1% SO₃, 0.32% total Fe₂O₃, 0.80% CeO₂, 3.0% TiO₂, 20ppm Cr₂O₃, and ppm MnO. FeO was in 0.08%. FeO/Fe₂O₃ was 0.25 in weight ratio expression. CeO₂/TiO₂ was 0.27 in weight ratio expression. The total of

SiO₂+Al₂O₃+Fe₂O₃+CaO+MgO+Na₂O+K₂O+SO₃+CeO₂+TiO₂+Cr₂O₃+MnO was in 99.9%. SiO₂+Al₂O₃+TiO₂ was in 73.3%. CaO+MgO was in 11.8%. Na₂O+K₂O was in 13.6%.

[0075] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 4.2%. 350nm wavelength transmittance (T_{350}) was in 0%. 550nm wavelength transmittance (T_{550}) was in 83%. 1100nm wavelength transmittance (T_{1100}) was in 30%. The visible light transmittance (T_v) by A light source was in 79%. The solar radiation transmittance (T_s) was in 53%. The dominant wavelength (D) by D₆₅ light source was in 595nm. Excitation purity (Pe) was in 6%.

(COMPARATIVE EXAMPLE 1-4)

[0076] Using glass raw materials almost similar to Example 1-1, the coloring raw materials in the glass composition were changed. As a result, the glass composition was in weight expression 70.1% SiO₂, 1.8% Al₂O₃, 8.2% CaO, 3.6% MgO, 12.6% Na₂O, 0.9% K₂O, 0.1% SO₃, 0.42% total Fe₂O₃, 0.5% CeO₂, and 0.5% TiO₂. FeO was in 0.21%. FeO/Fe₂O₃ was 0.5 in weight ratio expression. CeO₂/TiO₂ was 1.0 in weight ratio expression. The total of SiO₂+Al₂O₃+Fe₂O₃+CaO+MgO+Na₂O+K₂O+SO₃+CeO₂+TiO₂+Cr₂O₃+MnO was in 98.7%. SiO₂+Al₂O₃+TiO₂ was in 72.4%. CaO+MgO was in 11.8%. Na₂O+K₂O was in 13.5%.

[0077] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 15.0%. 350nm wavelength transmittance (T_{350}) was in 3.0%. 550nm wavelength transmittance (T_{550}) was in 75%. 1100nm wavelength transmittance (T_{1100}) was in 12%. The visible light transmittance (T_v) by A light source was in 72%. The solar radiation transmittance (T_s) was in 25%. The dominant wavelength (D) by D₆₅ light source was in 500nm. Excitation purity (Pe) was in 10%.

(COMPARATIVE EXAMPLE 1-5)

[0078] Using glass raw materials almost similar to Example 1-1, the parent composition, together with the coloring raw materials in the glass composition, was partly changed. As a result, there was obtained a glass having a composition in weight expression of 69.4% SiO₂, 1.6% Al₂O₃, 8.2% CaO, 3.6% MgO, 12.6% Na₂O, 0.9% K₂O, 0.1% SO₃, 0.28% total Fe₂O₃, 2.2% CeO₂, 1.0% TiO₂, 17ppm Cr₂O₃, and 2.2% ZnO. FeO was in 0.13%. FeO/Fe₂O₃ was 0.46 in

weight ratio expression. $\text{CeO}_2/\text{TiO}_2$ was 2.2 in weight ratio expression. The total of

$\text{SiO}_2+\text{Al}_2\text{O}_3+\text{Fe}_2\text{O}_3+\text{CaO}+\text{MgO}+\text{Na}_2\text{O}+\text{K}_2\text{O}+\text{SO}_3+\text{CeO}_2+\text{TiO}_2+\text{Cr}_2\text{O}_3+\text{MnO}$ was in 99.9%. $\text{SiO}_2+\text{Al}_2\text{O}_3+\text{TiO}_2$ was in 72.0%. $\text{CaO}+\text{MgO}$ was in 11.8%.

5 $\text{Na}_2\text{O}+\text{K}_2\text{O}$ was in 13.5%.

[0079] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 2.5%. 350nm wavelength transmittance (T_{350}) was in 0%. 550nm wavelength transmittance (T_{550}) was in 78%. 1100nm wavelength transmittance (T_{1100}) was in 35%. The visible light transmittance (T_v) by A
10 light source was in 78%. The solar radiation transmittance (T_s) was in 55%. The dominant wavelength (D) by D_{65} light source was in 595nm. Excitation purity (Pe) was in 11%.

(EXAMPLE 2-1)

[0080] As glass raw materials, there were used silica sand, feldspar, soda ash,
15 dolomite, limestone, mirabilite, rouge, titanium oxide, and cerium carbonate. Furthermore, there were also used chemical reagents of Al_2O_3 , Fe_2O_3 , CaCO_3 , MgCO_3 , Na_2CO_3 , K_2CO_3 , CeO_2 , TiO_2 and SnO , in addition to ilmenite and slug. Using these, a predetermined glass composition was previously set as a target composition, and they were weighed and mixed together. As a raw material
20 batch, mirabilite/(silicon sand + feldspar) was adjusted to about 1%, and cullet was adjusted to about 50%.

[0081] The same steps as those of Example 1-1 were conducted by using the above mixed raw material. The resulting sample was subjected to the same analyses as those of Example 1-1.

25 [0082] The glass composition was in weight expression 69.9% SiO_2 , 1.7% Al_2O_3 , 8.2% CaO , 3.6% MgO , 12.7% Na_2O , 0.9% K_2O , 0.1% SO_3 , 0.38% total Fe_2O_3 , 1.0% CeO_2 , 1.0% TiO_2 , 0.5% SnO and 17ppm Cr_2O_3 . FeO was in 0.17%. $\text{FeO}/\text{Fe}_2\text{O}_3$ was 0.5 in weight ratio expression. $\text{CeO}_2/\text{TiO}_2$ was 1.0 in weight ratio expression. The total of
30 $\text{SiO}_2+\text{Al}_2\text{O}_3+\text{Fe}_2\text{O}_3+\text{CaO}+\text{MgO}+\text{Na}_2\text{O}+\text{K}_2\text{O}+\text{SO}_3+\text{CeO}_2+\text{TiO}_2+\text{SnO}+\text{Cr}_2\text{O}_3+$

MnO was in 99.9%. $\text{SiO}_2+\text{Al}_2\text{O}_3+\text{TiO}_2$ was in 72.6%. $\text{CaO}+\text{MgO}$ was in 11.8%. $\text{Na}_2\text{O}+\text{K}_2\text{O}$ was in 13.6%.

[0083] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 6.0%. 350nm wavelength transmittance (T_{350}) was in 0.7%. 550nm wavelength transmittance (T_{550}) was in 75%. 1100nm wavelength transmittance (T_{1100}) was in 17%. The visible light transmittance (T_v) by A light source was in 71%. The solar radiation transmittance (T_s) was in 41%. The dominant wavelength (D) by D_{65} light source was in 525nm. Excitation purity (Pe) was in 4%. The measurement results of transmittance relative to wavelength are shown in Fig. 1. It is understood that transmittance of ultraviolet and infrared region is low and that it has a characteristic of ultraviolet absorption and infrared absorption.

(EXAMPLE 2-2)

[0084] Using glass raw materials almost similar to Example 2-1, an examination was conducted by changing the glass composition. As a result, the glass composition was in weight expression 69.7% SiO_2 , 1.6% Al_2O_3 , 8.2% CaO , 3.6% MgO , 12.6% Na_2O , 0.9% K_2O , 0.1% SO_3 , 0.47% total Fe_2O_3 , 1.0% CeO_2 , 1.0% TiO_2 , 0.6% SnO and 13ppm Cr_2O_3 . FeO was in 0.19%. $\text{FeO}/\text{Fe}_2\text{O}_3$ was 0.40 in weight ratio expression. $\text{CeO}_2/\text{TiO}_2$ was 1.0 in weight ratio expression. The total of $\text{SiO}_2+\text{Al}_2\text{O}_3+\text{Fe}_2\text{O}_3+\text{CaO}+\text{MgO}+\text{Na}_2\text{O}+\text{K}_2\text{O}+\text{SO}_3+\text{CeO}_2+\text{TiO}_2+\text{SnO}+\text{Cr}_2\text{O}_3+\text{MnO}$ was in 99.9%. $\text{SiO}_2+\text{Al}_2\text{O}_3+\text{TiO}_2$ was in 72.5%. $\text{CaO}+\text{MgO}$ was in 11.8%. $\text{Na}_2\text{O}+\text{K}_2\text{O}$ was in 13.5%.

[0085] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 4.5%. 350nm wavelength transmittance (T_{350}) was in 0.3%. 550nm wavelength transmittance (T_{550}) was in 73%. 1100nm wavelength transmittance (T_{1100}) was in 13%. The visible light transmittance (T_v) by A light source was in 71%. The solar radiation transmittance (T_s) was in 37%. The dominant wavelength (D) by D_{65} light source was in 530nm. Excitation purity (Pe) was in 4%.

(EXAMPLE 2-3)

[0086] Using glass raw materials almost similar to Example 2-1, an examination was continued by changing the glass composition. As a result, the glass composition was in weight expression 69.6% SiO₂, 1.6% Al₂O₃, 8.0% CaO, 3.7% MgO, 12.4% Na₂O, 1.0% K₂O, 0.1% SO₃, 0.32% total Fe₂O₃, 1.2% CeO₂, 1.5% TiO₂, 0.4% SnO, 7ppm Cr₂O₃ and 180ppm MnO. FeO was in 0.135%. FeO/Fe₂O₃ was 0.47 in weight ratio expression. CeO₂/TiO₂ was 0.8 in weight ratio expression. The total of SiO₂+Al₂O₃+Fe₂O₃+CaO+MgO+Na₂O+K₂O+SO₃+CeO₂+TiO₂+SnO+Cr₂O₃+MnO was in 99.8%. SiO₂+Al₂O₃+TiO₂ was in 72.7%. CaO+MgO was in 11.7%. Na₂O+K₂O was in 13.4%.

[0087] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 4.4%. 350nm wavelength transmittance (T₃₅₀) was in 0%. 550nm wavelength transmittance (T₅₅₀) was in 76%. 1100nm wavelength transmittance (T₁₁₀₀) was in 23%. The visible light transmittance (T_v) by A light source was in 72%. The solar radiation transmittance (T_s) was in 45%. The dominant wavelength (D) by D₆₅ light source was in 535nm. Excitation purity (Pe) was in 3%.

(EXAMPLE 2-4)

[0088] Using glass raw materials almost similar to Example 2-1, an examination was continued by changing the glass composition. As a result, the glass composition was in weight expression 70.1% SiO₂, 1.7% Al₂O₃, 8.2% CaO, 3.6% MgO, 12.6% Na₂O, 0.9% K₂O, 0.1% SO₃, 0.45% total Fe₂O₃, 1.0% CeO₂, 1.0% TiO₂, 0.2% SnO, 15ppm Cr₂O₃ and 184ppm MnO. FeO was in 0.158%. FeO/Fe₂O₃ was 0.30 in weight ratio expression. CeO₂/TiO₂ was 1.0 in weight ratio expression. The total of SiO₂+Al₂O₃+Fe₂O₃+CaO+MgO+Na₂O+K₂O+SO₃+CeO₂+TiO₂+SnO+Cr₂O₃+MnO was in 99.9%. SiO₂+Al₂O₃+TiO₂ was in 72.8%. CaO+MgO was in 11.8%. Na₂O+K₂O was in 13.5%.

[0089] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 5.1%. 350nm wavelength transmittance (T₃₅₀) was in 0%. 550nm wavelength transmittance (T₅₅₀) was in 76%. 1100nm wavelength

transmittance (T_{1100}) was in 24%. The visible light transmittance (T_v) by A light source was in 72%. The solar radiation transmittance (T_s) was in 47%. The dominant wavelength (D) by D_{65} light source was in 550nm. Excitation purity (Pe) was in 5%.

5 (EXAMPLE 2-5)

[0090] Using glass raw materials almost similar to Example 2-1, an examination was continued by changing the glass composition. As a result, the glass composition was in weight expression 69.6% SiO_2 , 1.6% Al_2O_3 , 8.2% CaO , 3.6% MgO , 12.6% Na_2O , 0.9% K_2O , 0.1% SO_3 , 0.38% total Fe_2O_3 , 1.5%
10 CeO_2 , 1.2% TiO_2 , 0.3% SnO , 16ppm Cr_2O_3 and 180ppm MnO . FeO was in 0.13%. $\text{FeO}/\text{Fe}_2\text{O}_3$ was 0.35 in weight ratio expression. $\text{CeO}_2/\text{TiO}_2$ was 1.3 in weight ratio expression. The total of
 $\text{SiO}_2+\text{Al}_2\text{O}_3+\text{Fe}_2\text{O}_3+\text{CaO}+\text{MgO}+\text{Na}_2\text{O}+\text{K}_2\text{O}+\text{SO}_3+\text{CeO}_2+\text{TiO}_2+\text{SnO}+\text{Cr}_2\text{O}_3+$
 MnO was in 99.9%. $\text{SiO}_2+\text{Al}_2\text{O}_3+\text{TiO}_2$ was in 72.4%. $\text{CaO}+\text{MgO}$ was in 11.8%.
15 $\text{Na}_2\text{O}+\text{K}_2\text{O}$ was in 13.5%.

[0091] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 4.2%. 350nm wavelength transmittance (T_{350}) was in 0%. 550nm wavelength transmittance (T_{550}) was in 77%. 1100nm wavelength transmittance (T_{1100}) was in 25%. The visible light transmittance (T_v) by A
20 light source was in 73%. The solar radiation transmittance (T_s) was in 47%. The dominant wavelength (D) by D_{65} light source was in 550nm. Excitation purity (Pe) was in 5%.

(COMPARATIVE EXAMPLE 2-1)

[0092] Using glass raw materials almost similar to Example 1, the coloring
25 raw materials in the glass composition were changed. As a result, the glass composition was in weight expression 71.1% SiO_2 , 1.9% Al_2O_3 , 8.3% CaO , 3.6% MgO , 13.0% Na_2O , 0.8% K_2O , 0.1% SO_3 , 0.54% total Fe_2O_3 , 0.1% TiO_2 , and 17ppm Cr_2O_3 . FeO was in 0.13%. $\text{FeO}/\text{Fe}_2\text{O}_3$ was 0.26 in weight ratio expression. $\text{CeO}_2/\text{TiO}_2$ was 0 in weight ratio expression. The total of
30 $\text{SiO}_2+\text{Al}_2\text{O}_3+\text{Fe}_2\text{O}_3+\text{CaO}+\text{MgO}+\text{Na}_2\text{O}+\text{K}_2\text{O}+\text{SO}_3+\text{CeO}_2+\text{TiO}_2+\text{SnO}+\text{Cr}_2\text{O}_3+\text{Mn}$

O was in 99.9%. $\text{SiO}_2+\text{Al}_2\text{O}_3+\text{TiO}_2$ was in 73.1%. $\text{CaO}+\text{MgO}$ was in 11.9%. $\text{Na}_2\text{O}+\text{K}_2\text{O}$ was in 13.8%.

[0093] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 29%. 350nm wavelength transmittance (T_{350}) was in 20%. 550nm wavelength transmittance (T_{550}) was in 79%. 1100nm wavelength transmittance (T_{1100}) was in 27%. The visible light transmittance (T_v) by A light source was in 76%. The solar radiation transmittance (T_s) was in 52%. The dominant wavelength (D) by D_{65} light source was in 500nm. Excitation purity (Pe) was in 3%. The measurement results of transmittance relative to wavelength, together with the results of Example 1, are shown in Fig. 1. Although it is a greenish glass, its transmittance of ultraviolet rays and infrared rays is high, and its characteristics are different from those of the ultraviolet and infrared absorptive glass of Example 1-1.

(COMPARATIVE EXAMPLE 2-2)

[0094] Using glass raw materials almost similar to Example 2-1, the coloring raw materials in the glass composition were changed. As a result, the glass composition was in weight expression 70.1% SiO_2 , 1.6% Al_2O_3 , 8.2% CaO , 3.6% MgO , 12.6% Na_2O , 0.9% K_2O , 0.1% SO_3 , 0.62% total Fe_2O_3 , 0.7% CeO_2 , 0.6% TiO_2 , 0.9% SnO , 35ppm Cr_2O_3 and 220ppm MnO . FeO was in 0.30%. $\text{FeO}/\text{Fe}_2\text{O}_3$ was 0.53 in weight ratio expression. $\text{CeO}_2/\text{TiO}_2$ was 1.2 in weight ratio expression. The total of $\text{SiO}_2+\text{Al}_2\text{O}_3+\text{Fe}_2\text{O}_3+\text{CaO}+\text{MgO}+\text{Na}_2\text{O}+\text{K}_2\text{O}+\text{SO}_3+\text{CeO}_2+\text{TiO}_2+\text{SnO}+\text{Cr}_2\text{O}_3+\text{MnO}$ was in 98.9%. $\text{SiO}_2+\text{Al}_2\text{O}_3+\text{TiO}_2$ was in 72.2%. $\text{CaO}+\text{MgO}$ was in 11.8%. $\text{Na}_2\text{O}+\text{K}_2\text{O}$ was in 13.5%.

[0095] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 10%. 350nm wavelength transmittance (T_{350}) was in 2.2%. 550nm wavelength transmittance (T_{550}) was in 65%. 1100nm wavelength transmittance (T_{1100}) was in 6%. The visible light transmittance (T_v) by A light source was in 60%. The solar radiation transmittance (T_s) was in 31%. The dominant wavelength (D) by D_{65} light source was in 506nm. Excitation purity (Pe) was in 5%.

(COMPARATIVE EXAMPLE 2-3)

[0096] Using glass raw materials almost similar to Example 2-2, the coloring raw materials in the glass composition were changed. As a result, the glass composition was in weight expression 68.5% SiO₂, 1.8% Al₂O₃, 8.2% CaO, 3.6% MgO, 12.7% Na₂O, 0.9% K₂O, 0.1% SO₃, 0.25% total Fe₂O₃, 0.9% CeO₂, 1.8% TiO₂, 0.9% SnO, 35ppm Cr₂O₃ and 180ppm MnO. FeO was in 0.10%.

FeO/Fe₂O₃ was 0.46 in weight ratio expression. CeO₂/TiO₂ was 0.5 in weight ratio expression. The total of

SiO₂+Al₂O₃+Fe₂O₃+CaO+MgO+Na₂O+K₂O+SO₃+CeO₂+TiO₂+SnO+Cr₂O₃+

MnO was in 99.9%. SiO₂+Al₂O₃+TiO₂ was in 73.3%. CaO+MgO was in 11.8%. Na₂O+K₂O was in 13.6%.

[0097] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 6.1%. 350nm wavelength transmittance (T₃₅₀) was in 0.3%. 550nm wavelength transmittance (T₅₅₀) was in 70%. 1100nm wavelength

transmittance (T₁₁₀₀) was in 29%. The visible light transmittance (T_v) by A light source was in 66%. The solar radiation transmittance (T_s) was in 54%. The dominant wavelength (D) by D₆₅ light source was in 540nm. Excitation purity (Pe) was in 5%.

(COMPARATIVE EXAMPLE 2-4)

[0098] Using glass raw materials almost similar to Example 2-1, the coloring raw materials in the glass composition were changed. As a result, the glass composition was in weight expression 70.1% SiO₂, 1.8% Al₂O₃, 8.2% CaO, 3.6% MgO, 12.6% Na₂O, 0.9% K₂O, 0.1% SO₃, 0.63% total Fe₂O₃, 1.8% CeO₂, 0.9% TiO₂, and 0.9% SnO. FeO was in 0.20%. FeO/Fe₂O₃ was 0.35 in weight ratio

expression. CeO₂/TiO₂ was 2.0 in weight ratio expression. The total of SiO₂+Al₂O₃+Fe₂O₃+CaO+MgO+Na₂O+K₂O+SO₃+CeO₂+TiO₂+SnO+Cr₂O₃+MnO was in 98.7%. SiO₂+Al₂O₃+TiO₂ was in 72.4%. CaO+MgO was in 11.8%. Na₂O+K₂O was in 13.5%.

[0099] The ultraviolet transmittance (T_{uv}) by ISO/DIS9050 at 5mm thickness was in 3%. 350nm wavelength transmittance (T₃₅₀) was in 0%. 550nm wavelength transmittance (T₅₅₀) was in 64%. 1100nm wavelength

transmittance (T_{1100}) was in 13%. The visible light transmittance (T_v) by A light source was in 59%. The solar radiation transmittance (T_s) was in 38%. The dominant wavelength (D) by D_{65} light source was in 530nm. Excitation purity (Pe) was in 7%.

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